GRADE 12 DIPLOMA EXAMINATION

Physics 30

January 1990

Alberta
EDUCATION

GRADE 12 DIPLOMA EXAMINATION
PHYSICS 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 70

This is a **closed-book** examination consisting of **two** parts:

PART A has 49 multiple-choice questions each with a value of one mark.

PART B has four written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

GENERAL INSTRUCTIONS

Fill in the information required on the answer sheet and the examination booklet as directed by the examiner.

You are expected to provide your own approved scientific calculator.

Carefully read the instructions for each part before proceeding.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET.

The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.

JANUARY 1990

PART A

INSTRUCTIONS

In this part of the examination, there are 49 multiple-choice questions each with a value of one mark. All numbers used in the questions are to be considered as the result of a measurement.

Read each question carefully and decide which of the choices **best** completes the statement or answers the question. Locate that question number on the separate answer sheet provided and fill in the space that corresponds to your choice. **Use an HB pencil only.**

Example

This diploma examination is for the subject of

A. Biology
B. Physics
C. Chemistry
D. Mathematics

Answer Sheet

A	B	C	D
①	●	③	④

If you wish to change an answer, erase your first mark completely.

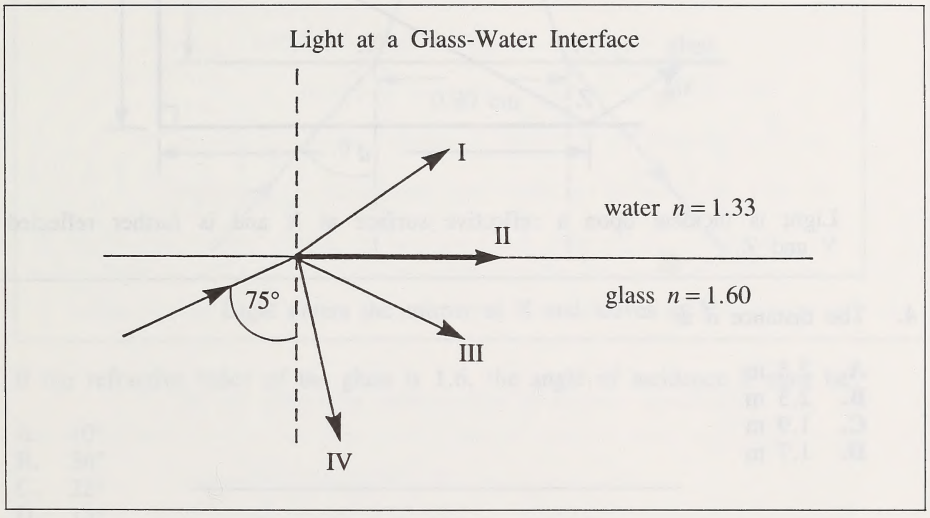
NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER.

1. Monochromatic light passes through a double slit of separation 1.5×10^{-4} m. If bright interference bands are 1.4×10^{-2} m apart on a screen that is 3.7 m from the double slit, the calculated wavelength of the light would be

A. 4.2×10^{-7} m
B. 5.4×10^{-7} m
C. 5.7×10^{-7} m
D. 6.2×10^{-7} m

Use the following information to answer question 2.



2. The correct path of the ray is shown by

A. I
B. II
C. III
D. IV

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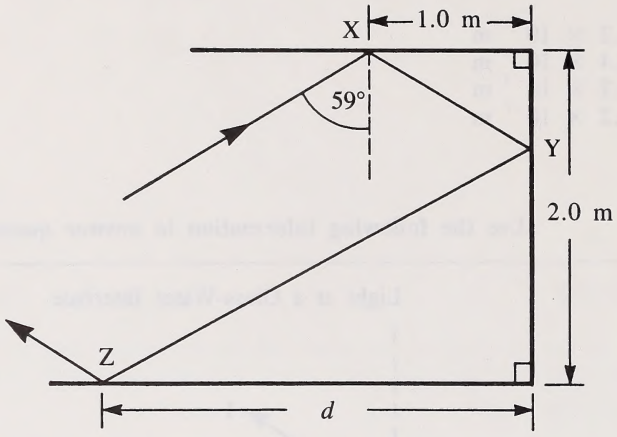
3. To determine the speed of light, Huygens used

A. toothed wheels
B. flashing lanterns
C. astronomical data
D. octagonal mirrors

Use the following information to answer question 4.



Light is incident upon a reflective surface at X and is further reflected at Y and Z.

4. The distance d is

A. 2.5 m
B. 2.3 m
C. 1.9 m
D. 1.7 m

---

5. If a spaceship could move at 1/1500th the speed of light, how long would it take to travel 2.50 light-years? (A light-year is the distance travelled by light in one year.)

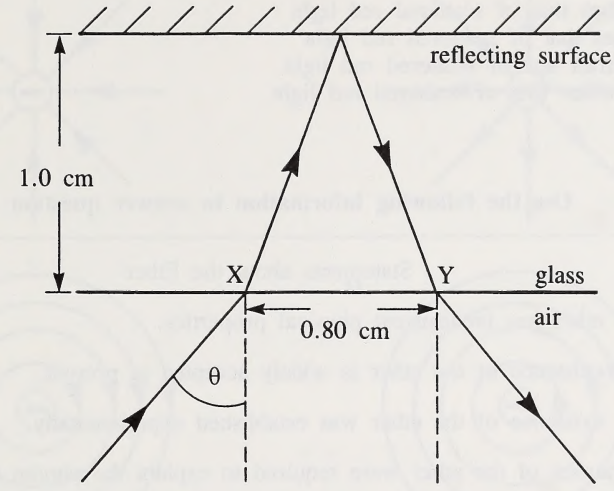
A. 3.75×10^{3} s
B. 1.18×10^{11} s
C. 8.46×10^{12} s
D. 3.56×10^{19} s

6. Wavelength is **not** a good criterion for categorizing light because wavelength

A. is inversely proportional to frequency
B. is directly proportional to speed
C. changes during diffraction
D. changes during refraction

Use the following information to answer question 7.

Reflection in a Thick Mirror



Light enters the mirror at X and leaves at Y.

7. If the refractive index of the glass is 1.6, the angle of incidence θ must be

A. 40°
B. 36°
C. 22°
D. 13°

---

8. Light passing from glass ($n = 1.5$) into water ($n = 1.3$) will

A. increase in both speed and wavelength
B. decrease in both speed and wavelength
C. increase in speed but decrease in wavelength
D. decrease in speed but increase in wavelength

9. The formation of the Poisson spot is a result of

A. refraction and destructive interference
B. diffraction and destructive interference
C. refraction and constructive interference
D. diffraction and constructive interference

10. The energy of scattered light is directly proportional to the fourth power of the frequency. If the frequency of violet light is twice that of red light, then the energy of scattered violet light would be

A. 16 times that of scattered red light
B. 8 times that of scattered red light
C. 1/8 times that of scattered red light
D. 1/16 times that of scattered red light

Use the following information to answer question 11.

Statements about the Ether
I. The ether has inconsistent physical properties.
II. The existence of the ether is widely accepted at present.
III. The existence of the ether was established experimentally.
IV. Properties of the ether were required to explain the photon model of light.

11. The statement(s) consistent with current views of the ether theory is(are)

A. I only
B. III only
C. I and II
D. II and IV

Use the following information to answer question 12.

Energy Beams
I. X-rays
II. Cathode rays
III. Red laser light
IV. Stream of alpha particles

12. Which energy beams can be deflected by an electric field?

A. I and II
B. I and III
C. II and IV only
D. II, III, and IV

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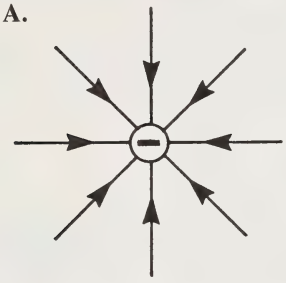
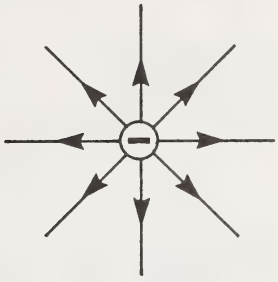
13. The electric field of an electron at rest may be **best** represented by

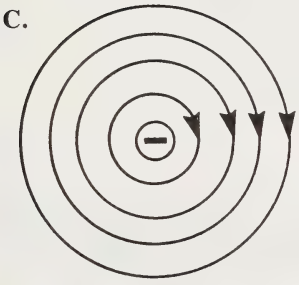
A.



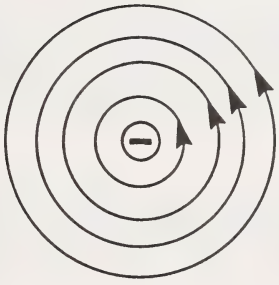
B.



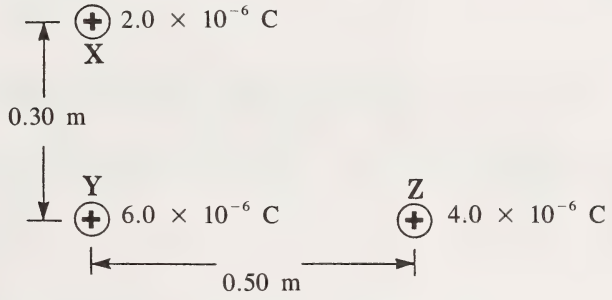
C.



D.



Use the following information to answer question 14.



Charges X, Y, and Z, with magnitudes as shown in the diagram, are placed at the vertices of a right-angled triangle.

14. The force on charge Y has a magnitude of

A. 2.1 N
B. 1.5 N
C. 1.0 N
D. 0.34 N

15. A charged oil drop of mass 1.9×10^{-15} kg is suspended in a vertical electric field of strength 6.0×10^{3} N/C. For equilibrium, the charge on the oil drop must be

A. 3.2×10^{-19} C
B. 3.1×10^{-18} C
C. 1.9×10^{-14} C
D. 1.1×10^{-11} C

16. A positively charged pith ball P will attract a neutral pith ball Q. This attraction occurs because the negative charge induced on Q is

A. larger than the positive charge induced on Q
B. smaller than the positive charge induced on Q
C. closer to P than the positive charge induced on Q
D. farther from P than the positive charge induced on Q

17. Two charged bodies repel each other with a force of F. The charge on one is doubled, and the charge on the other is increased by a factor of 7/3. If the distance between them is then tripled, the final resulting force would be

A. $42F$
B. $14F/3$
C. $14F/27$
D. $F/9$

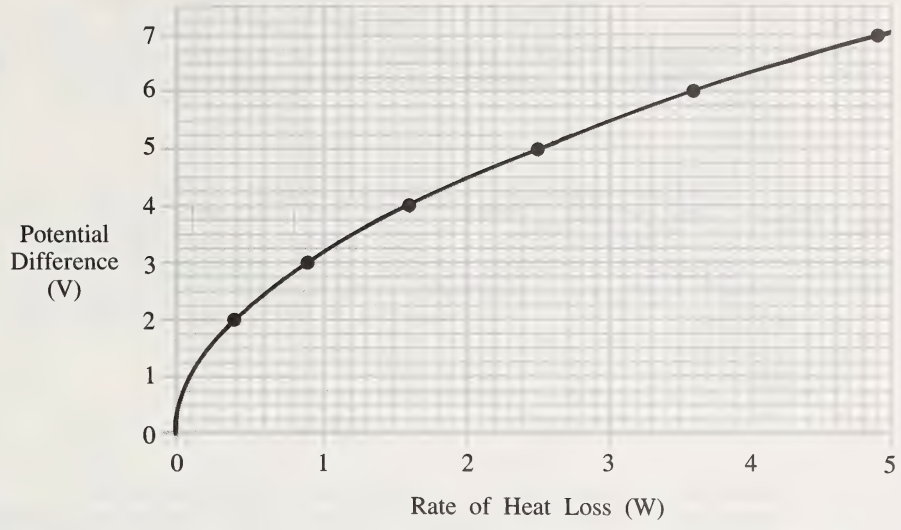
18. When 7.0×10^{-15} J of work are required to move an electron from one charged plate to another, the potential difference between the plates is

A. 4.4×10^{4} V
B. 2.3×10^{-19} V
C. 1.6×10^{-19} V
D. 1.1×10^{-33} V

19. When Ohm's Law applies, the current varies

A. directly as the voltage and directly as the resistance
B. directly as the voltage and inversely as the resistance
C. inversely as the voltage and directly as the resistance
D. inversely as the voltage and inversely as the resistance

Use the following information to answer questions 20 and 21.



The graph represents potential difference as a function of rate of heat loss for a fixed resistance.

20. The magnitude of the resistance is

A. 1.6 Ω
B. 2.5 Ω
C. 6.4 Ω
D. 10 Ω

21. What is the current through the resistance when the potential difference is 6.0 V?

A. 0.60 A
B. 1.7 A
C. 3.6 A
D. 22 A

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22. The magnetic force experienced by a charged particle moving through any magnetic field is

A. always greater than zero
B. constant regardless of the direction of the field
C. maximum when the velocity is parallel to the field
D. maximum when the velocity is perpendicular to the field

23. Magnetic field strength is measured in tesla (T). One set of units equivalent to 1 T is 1 N/(A•m). Another set of units equivalent to 1 T is

A. 1 J/C
B. 1 (N•C)/(m•s)
C. 1 (N•s)/(C•m)
D. 1 (kg•m)/(C•s)

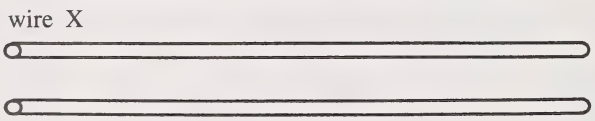
24. A beam of alpha particles is directed with a horizontal speed of 2.0×10^7 m/s into a mass spectrometer that has a vertical magnetic field strength of 3.0 T. What is the radius of the path of the beam in the spectrometer?

A. 0.072 m
B. 0.14 m
C. 0.28 m
D. 7.2 m

25. If a charged particle travelling at 3.00×10^6 m/s at right angles to a magnetic field of 0.125 T experiences a deflecting force of 1.20×10^{-13} N, the particle could be

A. a proton
B. a neutron
C. an electron
D. an alpha particle

Use the following information to answer question 26.



Parallel wires X and Y carry electric currents.

26. If the direction of the current in wire X is reversed, then

A. the current in wire Y would be reversed
B. only the magnetic force on wire X would be reversed
C. only the magnetic force on wire Y would be reversed
D. the magnetic forces on both wires X and Y would be reversed

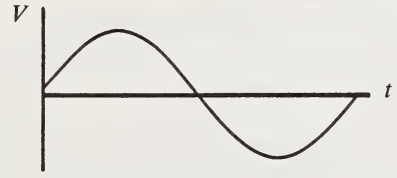
27. In a vacuum, the speed of all forms of electromagnetic radiation is

A. equal to the speed of light
B. the same as in all other media
C. inversely proportional to the frequency of the radiation
D. inversely proportional to the wavelength of the radiation

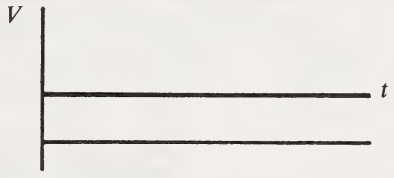
Use the following information to answer question 28.

A transformer induces a current in the secondary coil because of the magnetic field produced by the current in the primary coil. The graphs represent voltages applied to the primary coil of a transformer:

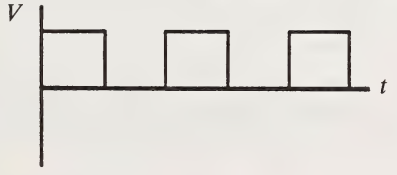
I.



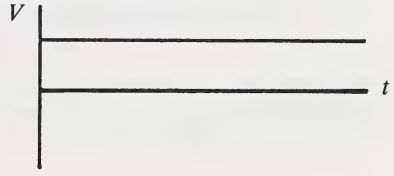
II.



III.



IV.



28. Which signals would cause the induction of a current in the secondary coil?

A. I and III
B. I and IV
C. II and III
D. III and IV

Use the following information to answer question 29.

Possible Descriptions of Light Waves
I. Transverse waves with the magnetic field direction at 180° to the electric field direction
II. Transverse waves with the magnetic field direction at 90° to the electric field direction
III. Longitudinal waves with the magnetic field direction at 180° to the electric field direction
IV. Longitudinal waves with the magnetic field direction at 90° to the electric field direction

29. The statement that correctly describes light waves is

A. I
B. II
C. III
D. IV

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30. A current of 0.60 A passes through a solution of copper(II) sulphate in an electrolytic apparatus. The time required to deposit 0.45 g of copper from the Cu^{2+} solution is calculated to be

A. 2.3 s
B. 5.0 s
C. 2.3×10^{3} s
D. 5.0×10^{3} s

31. The experimental value of q/m for a proton is 9.6×10^{7} C/kg. The value of q/m for an alpha particle is

A. 1.9×10^{8} C/kg
B. 9.6×10^{7} C/kg
C. 4.8×10^{7} C/kg
D. 2.4×10^{7} C/kg

32. An electric field of 4.3×10^{4} N/C and a perpendicular magnetic field of 1.3×10^{-3} T are applied simultaneously to a beam of electrons. If the beam remains undeflected, the speed of the electrons must be

A. 5.6×10^{-11} m/s
B. 3.0×10^{-8} m/s
C. 1.6×10^{4} m/s
D. 3.3×10^{7} m/s

33. To demonstrate that electric charges in nature are made up of whole-number multiples of the smallest charge, Millikan used

A. three forces: gravitational, magnetic, and electric
B. two forces: gravitational and electric
C. two forces: magnetic and electric
D. only the electric force

34. The Bohr theory **best** explains

A. the photoelectric effect
B. intensities of spectral lines
C. emission and absorption spectra of hydrogen
D. electric and magnetic effects on spectral lines

Use the following information to answer questions 35 and 36.

Observations in Photoelectric Experiments

I. The magnitude of the current increases.
II. The magnitude of the current decreases.
III. The magnitude of the current is constant.
IV. The energy of the photoelectrons increases.
V. The energy of the photoelectrons decreases.
VI. The energy of the photoelectrons is constant.

35. In a photoelectric experiment, a student increases the intensity of the incident light while maintaining a constant frequency. What are the effects on the magnitude of the photoelectric current and on the energy of the photoelectrons?

A. I and IV
B. I and VI
C. III and IV
D. III and VI

36. In a photoelectric experiment, a student decreases the intensity of the incident light while increasing its frequency. What are the effects on the magnitude of the photoelectric current and on the energy of the photoelectrons?

A. II and IV
B. II and V
C. III and IV
D. III and VI

37. Light with a frequency of 8.50×10^{14} Hz strikes a surface that has a work function of 3.00 eV. The maximum kinetic energy of an emitted photoelectron is

A. 5.6×10^{-19} J
B. 4.5×10^{-19} J
C. 4.0×10^{-19} J
D. 8.4×10^{-20} J

38. The stopping voltage for photoelectrons in a photoelectric cell is used to determine their

A. mass
B. energy
C. momentum
D. charge-to-mass ratio

39. An electron makes a transition from the fourth energy level of a hydrogen atom to the ground state. The wavelength of the radiation emitted is

A. 9.7×10^{-8} m
B. 1.2×10^{-7} m
C. 3.6×10^{-7} m
D. 4.9×10^{-7} m

40. The radius of the fourth Bohr orbit of the hydrogen atom is

A. 3.31×10^{-12} m
B. 1.32×10^{-11} m
C. 2.12×10^{-10} m
D. 8.46×10^{-10} m

41. The energy required to remove the outermost electron of a sodium atom is 5.1 eV. If an electron with a speed of 1.5×10^{6} m/s strikes and ionizes a sodium atom, the maximum possible kinetic energy of the incident electron after the collision would be

A. 1.3 eV
B. 5.1 eV
C. 6.4 eV
D. 11.5 eV

42. An inadequacy of the Bohr atomic model is that

A. a radius cannot be calculated for hydrogen
B. an electron energy cannot be calculated for hydrogen
C. the spectrum of hydrogen cannot be predicted accurately
D. the relative brightness of the spectral lines of hydrogen cannot be predicted accurately

Use the following information to answer question 43.

Statements from Various Models of the Atom
I. The atom is neutral.
II. The bulk of the volume is empty space.
III. A negative fluid creates the bulk of the volume.
IV. The positive charges have a much greater mass than the negative charges.

43. Which statements are consistent with current understanding of the atom?

A. I and IV only
B. III and IV only
C. I, II, and IV
D. II, III, and IV

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44. When will the rest mass of an object be greater than its relativistic mass?

A. Never
B. Only at low speeds
C. Only at high speeds
D. Only at the speed of light

45. The total potential difference through which a proton must be accelerated from rest to acquire a relativistic mass of 1.72×10^{-27} kg is

A. 9.7×10^{8} V
B. 9.4×10^{8} V
C. 1.4×10^{8} V
D. 2.8×10^{7} V

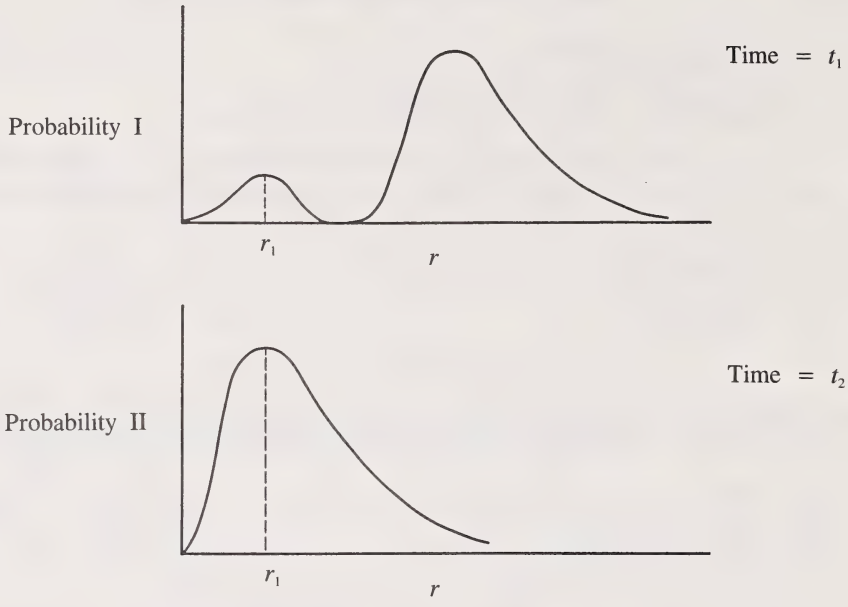
46. The momentum of an X-ray photon is directly proportional to its

A. mass
B. velocity
C. frequency
D. wavelength

47. An alpha particle and an electron are travelling at the same speed. The de Broglie wavelength for the alpha particle is

A. longer because of the greater mass of the alpha particle
B. shorter because of the greater mass of the alpha particle
C. longer because of the greater charge of the alpha particle
D. shorter because of the greater charge of the alpha particle

Use the following information to answer question 48.



The two diagrams represent the electron probability distribution for a hydrogen atom at different times. Probability II occurs some time later than Probability I.

48. Comparing the states of the hydrogen atom at the times t_1 and t_2, the change that has occurred in the atom is that

A. the average value of r has increased
B. the probability of finding the electron at $r = 0$ has increased
C. an electron has moved from the ground state to an excited state
D. an electron has moved from an excited state to the ground state

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49. Heisenberg's Uncertainty Principle states that the more accurately we know the position of a particle, the less accurately we know its

A. size
B. charge
C. amplitude
D. momentum

YOU HAVE NOW COMPLETED THE MULTIPLE-CHOICE PART OF THE EXAMINATION. PROCEED DIRECTLY TO PART B.

PART B

INSTRUCTIONS

In this part of the examination, there are four written-response questions for a total of 21 marks. All numbers used in the questions are to be considered as the result of a measurement.

Write your solutions in the examination booklet as neatly as possible.

Your solutions **must show all** pertinent explanations, calculations, and formulas. Full marks will be assigned **only** to those solutions that **show** all pertinent explanations, calculations, and formulas.

All numerical answers must be given correct to the appropriate number of significant digits.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

START PART B IMMEDIATELY.

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(4 marks)

1. The mass of Saturn is 94.8 times that of Earth, and its radius is 9.45 times that of Earth. If an object weighs 155 N on Earth, what will it weigh on Saturn? (Reminder: Marks **will** be deducted if the physics steps for the calculation are not explicitly shown.)

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2. The relativistic kinetic energy of a proton travelling at 2.76×10^8 m/s ($0.920c$) is K_1. A calculation using the classical Newtonian formula for kinetic energy gives the result K_2. Calculate the ratio K_1/K_2. Record your answer correct to three significant digits.

(5 marks)

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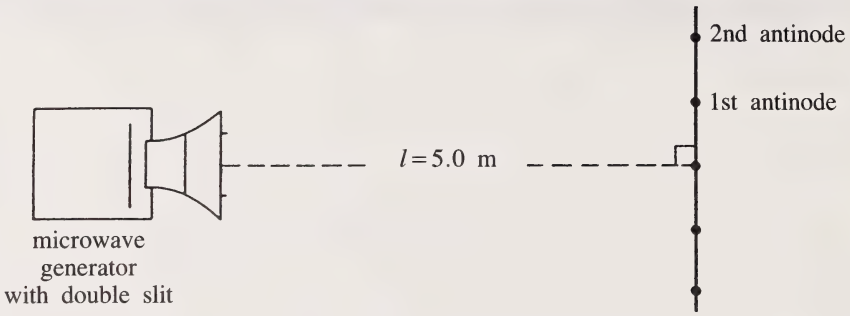
3. A microwave generator with a variable frequency f is used to measure the spacing d between two slits.



The distance x between the first antinode (maximum signal) and the central maximum at seven different frequencies is given in the table below:

f (10^{11} Hz)	x (cm)
4.0	3.6
3.0	4.8
2.0	7.4
1.3	12.0
1.0	14.2
0.75	20.4
0.60	24.6

(2 marks)

a. Draw a graph of distance x as a function of frequency f, with the manipulated variable on the horizontal axis.

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b. Re-plot the data in a manner that gives a straight line graph through the origin. Clearly label the variables plotted. You may use the data booklet value for the speed of light.

(3 marks)

c. Use a suitable averaging procedure to estimate the **best** value for the spacing d between the slits. You may use the data booklet value for the speed of light. Record your answer correct to two significant digits.

(2 marks)

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4. Both the classical wave model of light and the classical (Newtonian) particle model of light attempt to explain refraction.

(3 marks)

a. Compare and contrast the two explanations of the behavior of light as it passes from air to water.

Similarities:

Difference (in precise detail):

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b. Identify one piece of experimental evidence that supports **only one** of the classical models of light, stating which model is supported. Your evidence need **not** be restricted to refraction. **(1 mark)**

c. Some later experiments produced results that contradict **both** classical models of light. Name one such experiment and state its result. **(1 mark)**

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

TEAR-OUT PAGE

(NO MARKS WILL BE GIVEN FOR WORK DONE ON THIS PAGE)

FOLD AND TEAR ALONG PERFORATION

(NO MARKS WILL BE GIVEN FOR WORK DONE ON THIS PAGE)

TEAR-OUT PAGE

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TEAR-OUT PAGE

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FOLD AND TEAR ALONG PERFORATION

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M1 M2 M3 M4

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PHYSICS 30

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